EFFECT OF EARTHING MATERIAL WATER CONTENT ON THE RESISTIVITY AND CORROSION BEHAVIOUR OF EARTHING ELECTRODE

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SUPERVISOR'S DECLARATION

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor Degree of Civil Engineering

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STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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ABSTRAK

Tujuan utama sistem pembumian adalah untuk menyebarkan aliran caj ke muka bumi dalam masa yang paling singkat ketika berlakunya kilat ataupun litar pintas. Kerendahan frekuensi tentangan sistem pembumian menentukan kecekapannya. Oleh itu, sejumlah besar kajian telah dijalankan ke atas pelbagai jenis bahan untuk mencari bahan yang terbaik bagi sistem pembumian. Kajian ini bertujuan untuk menentukan kesan mempelbagaikan kandungan air terhadap daya tahan elektrik bahan pembumian, menentukan kesan sedutan terhadap tingkah laku kakisan elektrod tembaga dan aluminium yang ditanam di bawah bahan pembumian serta mengenal pasti jenis mikrob yang menyebabkan kakisan dan bertanggungjawab terhadap kakisan elektrod bumi dalam bahan pembumian. Dua sampel digunakan dalam kajian ini iaitu bentonite Andrassy dan Marconite. Sifat elektrik sampel telah dikaji dengan menggunakan kaedah kotak tanah dua-elektroda. Lengkungan ciri air-tanah (SWCC) sampel telah dibentuk menggunakan Teknik Keseimbangan Wap (VET). Ciri-ciri biologi sampel ditentukan melalui kaedah penyebaran plat. Hasil kajian menunjukkan bahawa daya tahan elektrik bentonite Andrassy sangat dipengaruhi oleh kehadiran air manakala daya tahan elektrik Marconite tidak terjejas oleh kehadiran air. Selain itu, Tindak balas kakisan elektrod aluminium dan tembaga tidak terjejas semata-mata oleh kandungan air bahan pembumian, sebaliknya ia dikawal oleh beberapa faktor lain seperti keadaan persekitaran, kandungan sulfur, pH, kehadiran mikroorganisma dan sebagainya. Kajian ini juga telah menemui mikrob yang menyebabkan kakisan, yang terdiri daripada satu spesies bakteria iaitu *Micrococcus luteus* dan empat spesies kulat iaitu *Paecilomyces lilacinus, Trichoderma atroviride, Fusarium proliferatum, Rhodotorula mucilaginosa*.

ABSTRACT

Electrical earthing systems main purposes is to disperse flow of charge to mother earth within the shortest time possible at the event of lightning or fault. Low frequency of earthing resistance of an electrical earthing systems determine its efficiency. Thus, there have been enormous amount of studies conducted on various material in order to find the best performing materials for an earthing systems. This study aims to determine the effect of varying water content on the electrical resistivity of earthing materials, determining the effect of suction on the corrosion behavior of copper and aluminium electrodes buried under earthing materials as well as identifying the type of corrosion induced microbes in earthing materials that is responsible for the corrosion of the earthing electrode. Two sample were used in this study namely Andrassy bentonite and Marconite. The sample electrical properties were studied by Wenner-four point test. The sample soil-water characteristic curve (SWCC) was established by Vapour Equilibrium Technique (VET). The sample biological characteristics was determined by means of spread plate method. The study outcome indicates that Andrassy Bentonite electrical resistivity is highly affected by water presence while Marconite electrical resistivity does not affected by the water presence. Aluminium and copper electrode corrosion behaviour is not affected solely by the water content of the earthing material, instead it is governs by a few other factors such as surrounding environment, sulphur content, pH, the presence of microorganisms and etc. One species of bacteria (i.e. *Micrococcus luteus*) and four species of fungus (i.e. *Paecilomyces lilacinus, Trichoderma atroviride*, *Fusarium proliferatum,* and *Rhodotorula mucilaginosa*) are the corrosion induced microbes that is responsible for corrosion of earthing electrode, identified in this study.

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LIST OF SYMBOLS

Ψ	Total suction
u_v	Partial pressure of water vapour
u_{v0}	Saturation pressure of pure water vapour
v_{w0}	Specific volume of water
ω_r	Molecular mass of water
R	Universal gas constant
T	Absolute temperature
RH	Relative humidity
G_s	Specific gravity
w_1	Mass of the density bottle and stopper
w_2	Mass of the density bottle, stopper and dry soil
w_3	Mass of density bottle, stopper, soil and water
w_4	Mass of density bottle, stopper and water
w	Water content
M_D	Mass of the dry soil
M_S	Mass of the wet soil
SL	Shrinkage limit
W	Moisture content of the wet soil sample
V_s	Volume of the dry soil sample
V	Volume of wet soil sample
W_s	Weight of the oven dried sample
K	A constant
T	Time of exposure
A	Area
W	Mass loss
D	Density
w_i	Hygroscopic water content
w_L	Liquid limit
w_P	Plastic limit
w_s	Shrinkage limit

LIST OF ABBREVIATIONS

MIC	Microbiologically induced corrosion
SWCC	Soil water characteristics curve
VET	Vapour equilibrium technique
BET	Brunauer-Emmett-Teller
CEC	Cation exchange capacity
NA	Nutrient agar
PDA	Potato dextrose agar

CHAPTER 1

INTRODUCTION

1.1 Introduction

Earthing plays a crucial role as a shield for power systems especially against lightning. The aim of an earthing system is to shorten the time for the dispersion of charge flow to the mother earth at the event of lightning or fault. It is vital to ensure a proper earthing installations, to avoid damage of equipment or improper operation, especially within solid-state equipment (Drive et. al, 2001).

The earthing systems performance is justified by its earthing resistance. In accordance with universally recognized standard, a lightning protection systems should sustain an earth resistance below a restrictive value of 1 Ωm (Transit et al., 2008; Transit et al., 2005). Hence, there are various method that have been widely used to surpass this obligatory value, including the use of the earth enhancement materials such as bentonite and Marconite conductive concrete as a backfill for earthing (Androvitsaneas, et al., 2016; Aydiner, 2009; Tshubwana, et al., 2017).

Bentonite demonstrates extremely lower resistivity in the wet condition (Gomes, et al., 2017) while Marconite have extremely low resistivity of 0.001 Ωm at its initial state. Bentonite ability in lowering the earth resistance is contributed by its excellent water absorption and retaining capability. Generally, soil suction refer to the ability of soil to attract and hold water. It has been acknowledged that the soil suction and water content are essential parameters that governs various properties of unsaturated soils (Nam et al., 2010). The wet condition in return depicts high moisture content which is the main factors that contribute to soil corrosion (Lim, et al., 2013).

Soil corrosion is influenced by physicochemical properties such as the type of soil, level of the water table and moisture content, resistivity of soil, soluble ion, pH of the soil, oxidation-reduction potential and the occurrences of microorganisms in soil (Lee, et al., 2017). Microorganisms tend to inhabit the metal surfaces, and further matures into biofilms to enhance the inhabitation process (Percival, 1997; San et al., 2014). The formation of biofilm is well-known phenomenon in the process industry as a mechanisms which possibly triggers microbiologically influenced corrosion (MIC) (San et al., 2014).

1.2 Problem Statements

There are several factors that governs the performance of earth enhancement material which include having a low resistivity, low permeability and naturally inert (Lim, et al., 2013a). In order to take full advantage of backfilling, the earth enhancement material should acquire preceding properties. The widely practice earth enhancement material worldwide including Malaysia is the Bentonite, which have been proved to exhibits a lower resistivity during wet conditions (Gomes et al., 2017; Lim et al., 2013a).

Permeability of the earth enhancement material relates to its suction, which is its ability to store water (Nam et al., 2010). Bentonite is recognized for its ability to hold water for a significant amount of time, contributing to its application as a backfilling materials (Lim et al., 2013a). However, the preceding properties may results in corrosion of the earthing electrode. Increased in soil moisture will extensively affects the process of corrosion (Abdulloev, et al., 2016).

Among the factor that can induced soil corrosion is the present of microbes which also term as microbiologically influenced corrosion (MIC). The corrosion process is influenced by the microorganisms in the manner of having a number of mechanisms operating instantaneously (Videla, 2001).

1.3 Objective

The objectives of this study are:

1) To determine the effect of varying water content on electrical resistivity of Andrassy bentonite and Marconite.

2) To determine the effect of suction on the corrosion behaviour of aluminium and copper electrodes buried under Andrassy bentonite and Marconite.

3) To identify the type of corrosion induced microbes in Andrassy bentonite and Marconite that is responsible for the corrosion of the earthing electrode.

1.4 Scope of Study

This study highlighted the use Andrassy bentonite and Marconite. The soil - water characteristic curve (SWCC) of Andrassy Bentonite and Marconite is established by vapour equilibrium technique (VET), particularly by applying suction of 3.60, 10.58, 23.58, 39.38, 111.77 and 262.75 MPa. Based on the water content of the SWCC the electrical resistivity of Andrassy bentonite and Marconite was determined by means of Wenner four - point test. The corrosion of the aluminium and copper electrode buried under Andrassy bentonite and Marconite will be determine by using mass - loss method and the type of corrosion induced microbes that is responsible for the corrosion of the earthing electrode will be determined by using spread plate method.

1.5 Significance of Study

It is of high expectation that this study will be a beneficial basis in uncovering the best performing earth enhancing material as a backfill material for earthing. The outcomes of the study may possibly be a resolution for problem encounter when using bentonite and Marconite as a backfill material for earthing. Especially, the one concerning the effect of the material water content on the resistivity and corrosion behaviour of earthing electrode as well as the possibility of corrosion cause by soil microbe which also known as Microbiologically Induced Corrosion (MIC). This in return will results in more effective earthing systems. The findings of the study is also expect to help further discover critical area or helps in generating idea on the part that is that yet to be explore.

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